NOTES ON THE CONCEPTUAL BASIS FOR CFT MODEL'S SEDIMENT FLUFF LAYER ALGORITHM IN SUPPORT OF DISCUSSIONS WITH USEPA ON DRAFT LPR RI COMMENTS

USEPA Required Revisions to CPG Modeling Approach include the following directive (3.d of Attachment 3): *"The presence or absence, thickness, and composition of the fluff layer must match the ST model".* The following notes are offered as clarification on the intent and design of the CFT fluff algorithm so as to facilitate discussion of why the ST layer tracking algorithm was not directly adopted in the CFT model.

The sediment fluff layer is conceptualized as a thin veneer of easily erodible sediment that dominates the intra-tidal cycling of suspended solids and contaminants between the bed and the water column. The CPG ST and CFT models account for this physical feature so as to capture its potential influence on the bed – water column exchange of solids and contaminants, and to allow these exchanges to be calibrated to water column measurements. The CFT layer tracking algorithm uses the ST model prediction of erosion/deposition fluxes, but did not use the ST model's "fluff layer" thickness directly because of differences in the phenomena that the ST and CFT model implementations seek to represent, as described below. It is emphasized that the term "fluff layer" is used differently in the ST and CFT models, which can potentially lead to confusion in communications on this topic.

The goal of the ST model's layer tracking algorithm is to distinguish the lower erodibility of material depositing at the sediment surface relative to underlying layers. As described in the text below (from Appendix M of the draft CPG RI), this is accomplished via a "fluff layer" and a "transitional layer", which may accumulate thicknesses up to 1 mm each on top of "deposited layers" and/or "parent bed layers":

> *Figure 36 shows a schematic of the revised bed layering along with a conceptual description of the hydrodynamic conditions that can potentially scour through the various strata. The fluff layer is located underneath the active layer (which is the layer at the interface between the bed and the water column) and is subject to erosion and deposition through the active layer. Under erosional conditions (e.g., the flood tide), the fluff layer may disappear due to resuspension. During the following depositional condition (e.g., slack water), the depositing sediments first recreate the fluff layer. When the fluff layer exceeds its pre-determined maximum thickness, the*

excess sediment is transferred to the underlying layer. Given the order of magnitude difference in strength between the fluff layer and the underlying parent or deposited layer, in order to avoid a discontinuity in strength and also for a better model-data comparison especially during spring tides, a transitional layer (with same thickness as the fluff layer) with intermediate strength was also introduced into the bed structure. New depositional layers are created immediately underneath the transitional layer, and under depositional conditions, sediment is transferred from the fluff layer through the transitional layer to the new depositional layer underneath. The deposited layers are subject to consolidation as described previously. Under erosional conditions, the layer depletion proceeds in a logical manner with the fluff layer eroded first, followed by the transitional layer and subsequently by the deposited or parent layer, as the case may be.

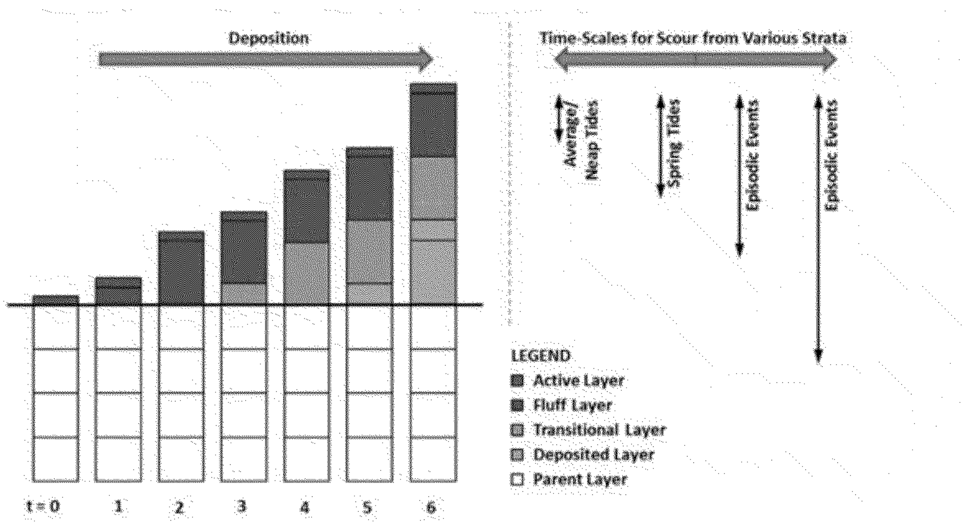

Figure 36. Schematic of revised bed layering in ECOM-SEDZLJS and conceptual representation of hydrodynamic conditions potentially responsible for erosion from various strata.

The goal of the CFT layer tracking algorithm is to account for potential gradients in contaminant concentration between the solids that are actively being resuspended/deposited each tidal cycle and solids in the underlying bed. As such, a CFT "fluff layer" dynamically tracks material that is participating in erosion/deposition over the tidal cycle, i.e., the solids that are "going up and down". The CFT fluff layer exchanges contaminant mass with the water column via erosion/deposition and with the underlying CFT bed layer via a diffusive mass transfer driven by the local concentration gradient (see figure below from the Draft RI report, Appendix O). There is also mass transfer of contaminant from the fluff layer to the underlying parent bed that occurs occasionally as a consequence of burial (when the fluff layer reaches its maximum thickness) and continually via a layer "thickness transfer" (or thickness decay). The latter process is implemented to ensure that, over the long-term, the CFT fluff layer adequately captures the thickness that is "going up and down" over the tidal cycles as described further below.

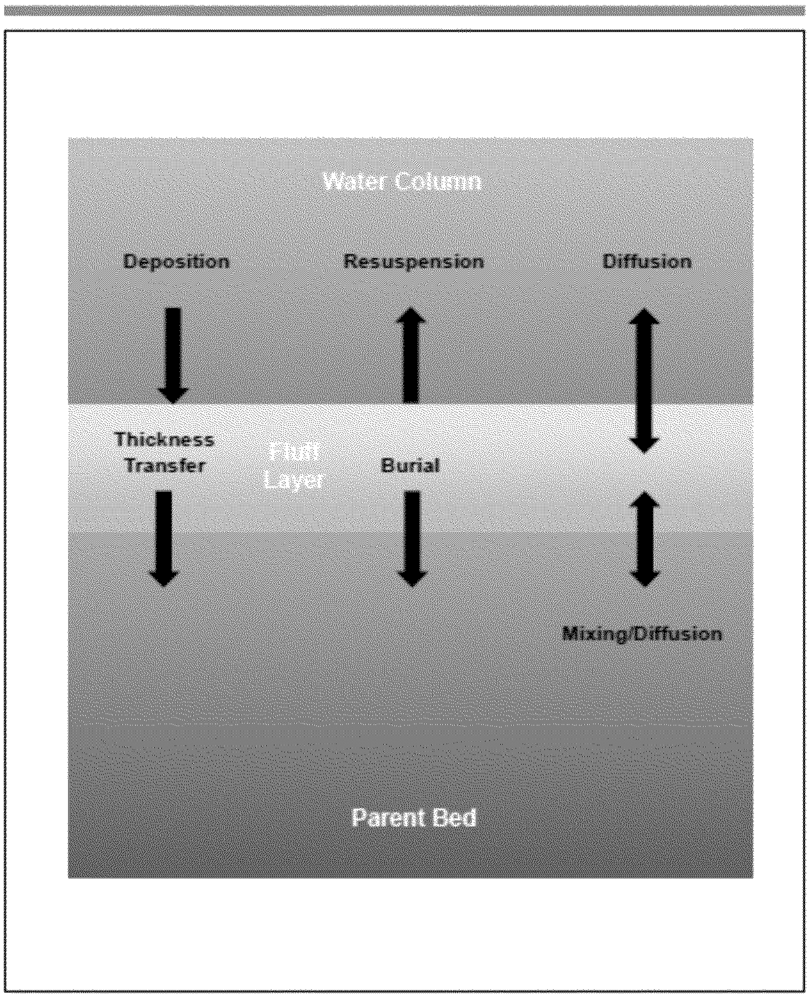

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Figure 2-1
Fluff Layer Mass Balance
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The CFT model algorithm does not use the ST "fluff layer" thickness because that layer does not necessarily reflect the material that is being resuspended and deposited each tidal cycle ("going up and down"). Rather, the ST model's "fluff" and "transitional" layers represent the reservoir of material that *could* be resuspended before the stiffer sediments of depositional or parent bed layers are encountered. The actual thickness of sediment that is being eroded/deposited over a tidal cycle depends on the initial fluff and transitional layer thicknesses and the prevailing shear stress conditions. It may correspond to any of the following:

- a portion of the ST fluff layer
- all of the ST fluff layer
- all of the ST fluff layer and a portion of the transitional layer
- all of the ST fluff and transitional layers (up to 2 mm thickness in current settings).

In principle the intratidal erosion/deposition thickness can extend into deposited layers, but this condition is likely much less frequent given the input critical shear stresses and erodibility.

The CFT "fluff layer" is designed to be able to expand to the total thickness of the ST model's "fluff" and "transitional" layers as needed (up to 2 mm in current ST settings), but also to contract dynamically via "thickness transfer" in order to gradually exclude the solids that are not actively participating in erosion/deposition. Specifically,

- As material deposits (e.g., as slack tide is approached), the CFT fluff layer thickness expands by the change in bed elevation computed by the ST model. It may expand up to a user-input maximum CFT fluff thickness (e.g., 2 mm). When this upper bound fluff thickness is reached, additional deposition is pushed to the underlying parent bed layer, causing it to expand. Accordingly, contaminant accumulates in the fluff layer during deposition and when the fluff layer reaches its maximum thickness, additional deposition causes contaminant mass to be passed to the surface layer of the parent bed.
- As material erodes (e.g., during the subsequent accelerating tide), the CFT fluff layer thickness contracts by the bed elevation change computed by the ST model. Once it is fully depleted (i.e., reaching a very small user-input minimum thickness defined for numerical reasons), additional erosion depletes the underlying parent bed layer.
- When the CFT fluff layer is present, the algorithm decays its thickness in accordance with a user-specified "thickness transfer" rate, corresponding to the rate at which the base of the fluff layer is incorporated into the underlying parent bed (see also Appendix O Section 2.1.1.2.4).

The thickness transfer is an important component of the algorithm because it allows the model to approximate the layer actively being eroded/resuspended. To illustrate this, consider the case where the CFT fluff layer grows to its maximum fluff thickness () due to a deposition event, but the subsequent fluxes from the ST model correspond only to a bed thickness oscillation of say 10% of for an extended period of time. In the absence of a fluff thickness decay, in this example there would be 90% of static fluff thickness that would over time equilibrate with the parent bed due to the diffusive chemical exchange. This equilibration would eventually result in fluff chemical concentrations and erosion fluxes similar to those that would be realized if the fluxes came directly from the parent bed, i.e., as if there were no fluff layer. These dynamics are illustrated conceptually in the figure below (from the Draft RI report, Appendix O), and are also the reason that the ST model's fluff and transitional layer thicknesses cannot be used directly in the CFT model.

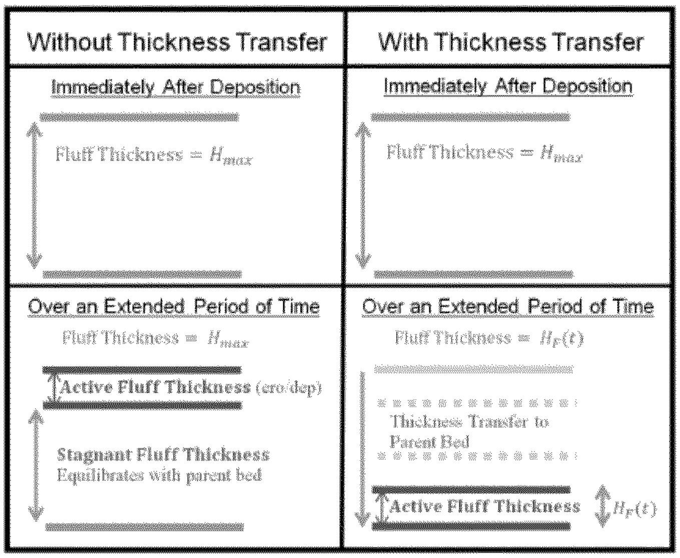

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Figure 2-3
Fluff Layer Equilibration and Thickness Transfer
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Overall, the CFT fluff algorithm may be thought of as an adaptive grid discretization approach that responds dynamically to the erosion and deposition fluxes computed from the ST model.